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NUTRITION OF THE DAIRY CALF

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The cost of raising dairy herd replacements assumes considerable economic importance in the United States. The National Dairy Herd consists of 17.6 millions of dairy cows that produce one calf each year. According to the 1960 census report 5.6 millions of heifer calves are raised each year in order to replace our National Dairy Herd. To grow this National Dairy Herd from birth to 2 years of age, by using modern minimal milk procedures, approximately 360 pounds whole milk, 760 pounds of concentrates, and 6 tons of hay are required. If we place a value of $6 per hundredweight on whole milk, $70 per ton on concentrates, and $30 per ton on hay, this would mean that the feed cost for each replacement would amount to $228 per animal over a 2-year period. This would mean an annual national cost of 650 millions of dollars to grow the cows to replace the National Dairy Herd.

According to present thinking, herd replacements should be grown at a sub-maximal rate. That is, instead of growing them for an extended period on milk and concentrates they are grown largely on forage feeds. While calves do not grow so rapidly and appear so sleek, they will usually reach normal size by the time they reach 2 years of age. By using this procedure the cost of raising herd replacements is considerably reduced.

A diagramatic feeding schedule for raising herd replacements using milk replacer and starter system is shown in Figure 1. Usually whole milk is fed at about 1 percent of body weight requiring about 350 to 380 pounds per calf. In this new system, instead of feeding calves the whole milk up to 8 weeks of age, the milk replacer is substituted when they are about 10 days old. A calf starter is offered beginning at about 10 to 20 days of age and is increased gradually up to a maximum of about 3 pounds per day. A herd ration is substituted for the starter at 3 months of age. The herd ration is gradually decreased beginning at 5 months of age and is discontinued at the end of 9 months of age. A good quality hay is offered at about 20 days of age. The calf should be fed as much as it will consume. If only poor quality hay is available, more starter or herd ration

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should be fed and the herd ration continued to calving time. If grass silage is fed as the only forage, the herd ration in amounts of 3 to 4 pounds should be fed to calving time. When good pasture is available, it should replace the hay fed.

This method of raising herd replacements likewise fits in with the philosophy of growing animals at a sub-maximal rate so that they will remain in herds for longer periods. Present studies in the United States and Europe indicate that cows grown at a maximal rate do not remain in the herd for as long a period of time as those grown at a sub-maximal rate. This does not mean that feed should be withheld to the point of stunting. A rate of growth should be attained in which the calves appear healthy but not necessarily fat and sleek.

The feeding of the dairy calf can be divided into two phases. The first phase is from birth to 3 months of age. The first 3 days of its life the calf remains with its dam and receives colostrum milk. From the fourth day to the 3-month period is the most critical in the rearing of the dairy calf since this is the period when losses occur. Sometimes these losses may amount to 5 to 15 percent or more of the calves being reared.

During this first phase the calf is considered a nonruminant or a monogastric animal. The rumen, reticulum, and omasum are relatively small in size at this early age compared to the abomasum or "true" stomach. The young calf, therefore, has many requirements for various nutrients including vitamins which are not required after the animal becomes a full-fledged ruminant.

It is difficult to pinpoint the time when a growing calf becomes a true ruminant. The process is a very gradual one. Some data collected at Beltsville would indicate that the bacterial population in the rumen becomes more or less normal by the time the calf reaches 6 weeks to 2 months of age. Data also indicate that forage is a necessary part of the ration in order for the calf to fully develop from the nonruminant to the ruminant stage.

During the first phase of growth from birth to 3 months the calf has particular requirements for protein, energy, vitamins, and minerals. Each requirement is discussed in the light of our present knowledge. This discussion is limited largely to the first phase of growth -- from birth to 3 months -- because this is the most critical stage insofar as the nutrition of the calf.

The second phase in the rearing of the dairy calf is from 3 months to 24 months of age. During this period the calf has become a full-fledged ruminant and can consume the same feeds as consumed by mature cows.

Table 1 shows daily nutrient requirements and table 2 shows nutrient content of rations for dairy cattle as published in the National Research Council (N.R.C.) Report for 1958.

TABLE 1.--Daily nutrient requirements of dairy cattle
(Based on air-dry feed containing 90-percent dry matter)

Body wgt.	Daily gain: Small breeds	Daily gain: Large breeds	Daily nutrients per animal: Feed	Protein	Digestible Protein	TDN	DE[1]	Ca	P	Carotene	Vit. D
Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Therm	gm.	gm.	mg.	I.U.
NORMAL GROWTH OF DAIRY HEIFERS											
50	0.5	----	0.9	0.31	0.20	1.0	2.0	4	3	2[2]	150
100	1.0	0.8	2.0	0.62	.40	2.0	4.0	7	6	4	300
150	1.3	1.4	4.0	0.78	.50	3.0	6.1	12	10	6	450
200	1.4	1.6	6.0	0.94	.60	4.0	8.1	13	10	8	600
400	1.2	1.8	11.0	1.25	.80	6.5	13.1	13	12	16	---

1/ DE (digestible energy) was calculated on the assumption that 1 gram of TDN has 4.4 kcal. of digestible energy (2000 kcal./lb.), a value based largely on the extensive summary of published data made by B. H. Schneider. DE may be converted to metabolizable energy by multiplying by 82 percent.

2/ Calves should receive colostrum the first few days after birth, as a source of vitamin A and other essential factors.

TABLE 2.--Nutrient content of rations for dairy cattle
(Based on air-dry feed containing 90-percent dry matter)

Body wgt.	Average age		Percent of ration or amount per pound of feed								
	Small breeds	Large breeds	Total daily feed	Feed % of wgt.	Digestible Protein	TDN	DE 1/	Ca	P	Carotene	Vit. D
Lb.	Months	Months	Lb.	Pct.	Pct.	Pct.	Therm./lb.	Pct.	Pct.	Mg./lb.	I.U./lb.
NORMAL GROWTH OF DAIRY HEIFERS											
50	Birth	-----	0.9	1.6	22.0	110	2.22	0.98	0.73	-----	170
100	2.3	0.6	2.0	2.0	20.0	100	2.02	.77	.66	2.0	150
150	3.7	2.0	4.0	2.7	12.5	75	1.52	.66	.44	1.5	110
200	4.8	3.1	6.0	3.0	10.0	67	1.35	.48	.40	1.3	100
400	10.0	6.7	11.0	2.8	7.3	59	1.19	.26	.30	1.5	---

1/ DE (digestible energy) may be converted to metabolizable energy by multiplying by 82 percent.

Source: National Research Council Report 1958.

Protein

Let us first consider the protein needs. The first protein which the calf receives is in the form of colostrum milk. This protein has high biological value and gives the calf its normal protein needs for this period. The colostrum protein contains certain antibodies that enables the calf to withstand bacterial infections. Calves that do not receive colostrum will usually not survive but will die of some acute infection.

Following the colostrum period, the calf receives whole milk which contains approximately 3-1/2 percent protein which is of high biological value. If calves are shifted from whole milk to milk replacers, the replacers usually contain some form of milk proteins such as dried skim milk, dried whey, or dried buttermilk. These dried products make up 60 to 90 percent of the milk replacer so that the protein source is still from milk. The substitution of vegetable protein in place of milk protein in the milk replacer has not been too successful. The milk replacers usually contain about 25 percent protein. The calf starter usually contains 20 to 25 percent protein from both milk and vegetable sources. By the time the starter is consumed in any amount the calf can fully utilize the vegetable proteins.

Energy

The energy the calf receives from milk is in the form of lactose and fat, the calf's natural energy source. The young calf is not able to digest some sugars because certain enzymes necessary for the degredation of the sugars or other forms of energy are not secreted in the digestive tract. It is able to handle glucose or lactose in a satisfactory manner, but cannot handle sucrose or maltose or starch. Therefore, in building milk replacers this factor needs to be taken into consideration. Following the milk feeding period other forms of energy may be present in the starter although if skim milk powder is used lactose continues to be an energy source. By the time the calf is consuming any amount of starter, it has developed the ability to digest and utilize other energy sources such as starch.

In a similar manner, the calf has certain limitations on the type of fat it can utilize. The calf can handle, of course, milk fat which is largely a saturated fat. However, it does have limited ability to handle the highly unsaturated fats such as corn oil and soybean oil. Such fats will usually cause deaths in calves if homogenized into liquid skim milk and fed in amounts larger than 2 percent of the milk. Some calf replacers contain 10 to 20 percent of animal fats which can be utilized by the dairy calf. Usually the replacer should contain 2 percent soybean lecithin to aid in the dispersion and digestibility of the fat.

VITAMINS

The mature dairy cow is most unique in that she is able to synthesize many of the vitamins that are usually required by monogastric animals. This synthesis is mediated through the action of the bacteria in the rumen. For instance, the bacteria can synthesize vitamin B_{12} on the substrate in the paunch providing the ration contains a sufficient amount of cobalt. However, the new-born calf, as previously mentioned, is a nonruminant at birth since the rumen while present is miniature in size. Thus, the new-born calf has requirements for vitamins much the same as other monogastric animals. The studies, which have been conducted from birth with young calves using synthetic diets, have demonstrated that they require thiamine, riboflavin, biotin, niacin, choline, pyridoxine, folic acid, B_{12} and pantothenic acid. We have no direct information on their requirements for para-aminobenzoic acid and vitamin K. The above may be classed as water-soluble vitamins. In addition, the calf has needs for the fat soluble vitamins, namely vitamins A, D and E.

The needs of the new-born calf for these vitamins which we have enumerated are supplied from the colostrum milk, which the calf receives shortly after birth and whole milk. Where milk replacers are used some further consideration must be given to vitamin needs. Yet, since dried milk products usually make up 60 to 90 percent of the dry matter of milk replacers, the requirements for the water-soluble vitamins are largely met. However, these dried milk products do not contain milk fat since it is removed in the processing. Therefore, we must consider the requirements for the fat-soluble vitamins during this early phase of growth.

<u>Vitamin A</u> -- Young calves that do not get enough vitamin A for the early phases of growth, usually die of scours and pneumonia. If they survive early calfhood, and their vitamin A intake is especially low, they are apt to show poor condition, grow slowly, have diarrhea and convulsions, and may even become blind. Even though enough vitamin A is fed to produce good growth and apparently healthy calves there still may be a partial deficiency that can be detected only by direct ophthalmoscopic examination of the eye or by determining the vitamin A content of the blood plasma which will be low. Vitamin A is important to health and growth of the young calf.

The young calf enters the world with a fairly low storage of vitamin A. However, the colostrum milk which the calf first receives is a rich source of vitamin A. Table 3 shows the effect of feeding whole milk in place of colostrum on blood plasma, vitamin A, and carotene of new-born calves. It will be noted that the vitamin A

in the blood plasma increased very slowly during the first week of feeding. On the other hand, table 4 shows the effect of feeding colostrum on the blood plasma vitamin A and carotene of new-born calves. In this table, it will be noted that the vitamin A level in the blood plasma reached quite a high level in a matter of 2 or 3 days in contrast to the rather low figures when whole milk was fed.

TABLE 3.--Effect of feeding whole milk in place of colostrum on blood plasma vitamin A and carotene of new-born calves

	Amount per 100 milliliters of plasma					
	Holstein		Holstein		Guernsey	
Age	Vitamin A	Carotene	Vitamin A	Carotene	Vitamin A	Carotene
Days	µg.	µg.	µg.	µg.	µg.	µg.
0	2.7	2.0	0.6	1.0	3.6	4.0
1	3.0	3.0	1.8	1.0	3.9	4.0
2	3.9	6.0	3.9	5.0	---	---
4	6.0	8.0	1.8	4.0	---	---
5	4.6	6.0	1.2	9.0	---	---
6	4.5	8.0	3.0	7.0	---	---
7	6.9	10.0	2.7	9.0	---	---

TABLE 4.--Effect of colostrum on the blood plasma vitamin A and carotene of new-born Holstein calves

Age	Animals	Vitamin A	Carotene
Days	No.	Mg.	Mg.
0 (Birth)	17	3.3 + 0.48	1.8 + 0.11
1	17	15.6 + 1.80	14.9 + 0.64
2	16	16.8 + 1.34	17.4 + 0.63
3	17	15.9 + 1.32	18.8 + 0.59
4	16	15.0 + 1.44	19.1 + 0.77
5	15	14.4 + 1.47	18.7 + 0.56
6	16	13.2 + 1.26	17.4 + 0.44
7	13	13.8 + 0.84	16.5 + 0.41

After the colostrum feeding period the requirements for additional vitamin A for the young calf have not been too well defined. Some work conducted at Beltsville many years ago is shown in table 5. It was found that the minimal requirement was about

TABLE 5.--Vitamin A requirements for young calves

Animal No.	Vitamin A per pound body wgt. daily	Percent of normal weight at					Result
		Birth	30 days	60 days	90 days	120 days	
	Mg.						
136-H	3.4	85	69	----	----	----	Died at 75 days.
349-H	3.4	80	81	77	72	74	Died at 175 days.
431-J	4.5	97	82	69	----	----	Died at 63 days.
1906-J	4.5	123	99	95	89	89	Deficiency symptom.
348-H	7.0	116	90	85	85	85	Slow growth.
1909-J	10.3	80	74	65	55	42	Continuous scours.
1758-H	10.3	100	----	----	----	----	Died at 21 days.
246-H	17 (25)1/	94	85	87	98	101	Normal.
247-H	17 (25)1/	91	80	83	87	91	Do.
415-J	48 (110)1/	80	95	101	98	104	Do.
316-J	48 (110)1/	100	103	107	115	110	Do.

1/ Two calves, 246-H and 247-H, received 10 milliliters of cod-liver oil daily for an average intake of 17 micrograms of vitamin A per pound for 6 months or an average of 25 micrograms for the first 2 months; 415-J and 316-J received 20 milliliters of cod-liver oil daily in the same manner.

25 micrograms of vitamin A per pound of body weight during the first 2 months. Further information on the need for vitamin A during this period is shown in table 6 in which calves received varying amounts of vitamin A in addition to the usual feeds fed to calves such as milk, grain and good hay. They were placed on a vitamin A deficient

TABLE 6.--Effect of vitamin A intake on depletion time

Animal number	Treatment	Depletion days
278	With dam on pasture to 90 days of age	120
329	Do.	113
708	50,000 I.U. to 98 days of age	125
513	50,000 I.U. to 92 days of age	106
517	50,000 I.U. to 40 days of age	98
2399	50,000 I.U. to 35 days of age	69
2707	50,000 I.U. to 30 days of age	53
515	50,000 I.U. to 30 days of age	45
512	No extra vitamin A	39
518	Do.	32
516	Do.	30
519	Do.	26
2703	Do.	24
520	Do.	17
2700	Do.	16
711	Do.	15

diet at 90 days of age to determine the length of time necessary to deplete their stores. It will be noted in this table that when calves were permitted to suckle the dam for 90 days while on pasture, they had sufficient store of vitamin A to last for 120 days. This would be comparable to natural conditions and forms a basis of comparison. However, when 50,000 I.U. (international unit) of vitamin A was fed for varying periods, the store was sufficient to last for 45 to 125 days depending upon the length of time the vitamin A supplement was fed. When no vitamin A was fed, the calves had sufficient store to last for only 13 to 39 days of age. This table points up the need for vitamin A supplementation during the first 3 months of the calf's life.

From the information available, it is recommended that calves should receive, during the first 4 to 6 weeks of life, a supplement of about 5,000 micrograms of vitamin A, or about 20,000 I.U. per day. This can be supplied in capsule form or, as is the usual practice, by mixing the vitamin A concentrate into the milk replacers to supply these amounts of vitamin A daily.

The calf starter usually contains some vitamin A source either in the form of a vitamin A concentrate or as carotene in the form of dehydrated alfalfa meal. It should be kept in mind that it takes about 4 micrograms of carotene to equal 1 microgram of vitamin A. In table 2 the NRC recommends that the ration should contain 2.0 mg. of carotene per pound of feed.

Vitamin D -- The vitamin D intake during the first 3 months of the calf's life is most important. The actual development of deficiency symptoms of vitamin D may not occur until later. If, however, the deficiency is sufficiently severe, stiffened gait, arched back, and tetany may develop, and sometimes the appetite may be affected adversely. In the deficiency usually the blood plasma will show lowered levels of calcium or phosphorus or both. There will also be a concomitant increase in the phosphatase level in the blood.

The minimal requirement for vitamin D is about 1 I.U. per pound of body weight. It is generally recommended, however, that under practical conditions the requirements should be about 3 I.U. per pound of body weight. Milk replacers and calf starters should contain some added vitamin D. This can be added in several forms, irradiated yeast being one of the common forms of addition. The milk replacers should contain about 300 I.U. per pound of feed, although some contain 10 times this amount.

Vitamin E -- The vitamin E deficiency symptoms are denoted by muscular weakness and may be confused in the early stages with the development of rickets. The muscular weakness is due to degeneration of the skeletal muscle fibers, and may occur in a sub-acute condition and go unnoticed. Chewing and swallowing may be impaired because of degeneration of the muscles in the region of the throat and mouth. At autopsy the muscles have a white or fried appearance and lack the natural reddish color. Histologically the muscular fibers show marked fragmentation and finally deposition of calcium salts occurs in the degenerated fibers.

Vitamin E deficiency is sometimes complicated by other factors. For instance, the deficiency can be produced experimentally by feeding 1 to 3 ounces of codliver oil per day. Recently, it has been demonstrated in certain Western States that the addition of a very small amount of selenium prevents the condition from developing.

Vitamin E is furnished by tocopherols which are present in the feeds. There are four different tocopherols but alpha-tocopherol is the most common and the one with the greatest amount of biological activity.

The requirements for vitamin E for calves are not well defined. The minimum requirement appears to be about 10 milligrams per 100 pounds body weight. In certain experiments at Beltsville, it has been found necessary to feed as much as 40 to 50 milligrams per 100 pounds of body weight to young calves. Milk replacers and starters should contain some added **vitamin E in amounts to furnish** 40 **to** 50 milligrams per day. Vitamin E occurs naturally in the greens and forages. Generally speaking, after 3 months of age the calf will receive sufficient vitamin E from the forages and concentrates. The chemically determined tocopherol in dehydrated alfalfa meal is about 90 percent available to the calf.

As previously indicated, selenium apparently has some relationship to muscular dystrophy in some areas of the West. Sometimes growing cattle and sheep develop muscular dystrophy even though the ration contains an adequate amount of vitamin E. The dystrophy can be prevented with a small amount of selenium. Recent experiments from England also indicate that a very small amount of selenium will prevent muscular dystrophy in calves. However, because selenium is toxic, no general recommendation for supplementation of this element can be made at this time.

MINERALS

Calves, insofar as we know, require the same minerals for growth as do other mammals. During the milk feeding period most minerals are present in adequate amounts except for some of the minor elements such as copper and iron. After the milk feeding period, there is need to give attention to calcium, phosphorus, magnesium, and sodium chloride.

Calcium and Phosphorus -- A deficiency of either of these elements causes development of rickets similar to that described in vitamin D deficiency. Usually the deficiency symptoms may not be obvious until about 3 or 4 months of age.

The requirements for calcium and phosphorus for the very young calf are about 7 or 8 grams per 100 pounds of body weight. It should be kept in mind that a sufficient amount of vitamin D must be present in the ration in order for the calcium and phosphorus to be effectively utilized.

Since milk replacers contain milk products, there is an adequate amount of calcium and phosphorus during the milk feeding period. After the milk feeding period, the calf starters which are used should contain some added calcium and phosphorus in the form of 1 or 2 percent of bonemeal or deflourinated phosphate.

Magnesium -- A deficiency of magnesium results in lowered blood magnesium levels which, if prolonged, will lead to tetanic consulsions and may result in the death of the calf. In a chronic state of the deficiency, there is a marked arteriosclerosis with deposition of calcium salts in the blood vascular system. Histologically this is seen to be due to a degeneration of the yellow elastic fibers in the blood vessels. The deficiency is quite likely modified by other factors such as the calcium and phosphorus content of the rest of the ration. Since the symptoms are due to a lowered blood magnesium, the deficiency is also related to grass tetany in mature cows. The deficiency may occur in calves kept on whole milk for extended periods of time because they do not consume forages and concentrates which contain magnesium. The deficiency is not likely to occur under practical farm conditions with usual rations. The requirement for magnesium for calves is about 20 to 25 milligrams per pound of body weight.

Sodium chloride -- Common salt should not be forgotten as one of the essential mineral constituents of the calf's diet. A mineralized salt should be added to the starter mixture. Salt may also be offered free choice in a box or in block form.

MINOR ELEMENTS

The need for minor elements in calf nutrition has received some attention during the past decade. Those elements that appear to be of greatest concern in calf nutrition are cobalt, copper, and iron. The relationship of selenium, another minor element, to vitamin E has already been mentioned.

Cobalt -- The requirement for cobalt in the diet of the very young calf is not known. Since cobalt is essential for the synthesis of vitamin B_{12} and since milk contains adequate B_{12}, it is unlikely that there is need for supplementation of this particular element while calves are on a milk diet. However, after the milk feeding period cobalt should be added to the starter ration. It is recommended that cobalt sulfate be added to the salt used in the calf starter at the rate of 1 ounce per 100 pounds of salt.

Iron -- A deficiency of iron in the diet of young calves causes a lowering of hemoglobin level and a slowed rate of growth. Studies at Beltsville have shown that some calves, under what is considered normal farm conditions, have lowered hemoglobin levels and that supplementation with iron brings about an increase in the hemoglobin in the blood. Data in this regard are shown in table 7. If such

TABLE 7.--Average hemoglobin levels of calves before and after supplementation with the minerals under investigation

			Supplements given			
Time Interval	All 4 minerals 2 calves	Iron 5 calves	Manganese 4 calves	Copper 4 calves	Cobalt 3 calves	Folic acid 2 calves
	(grams hemoglobin per 100 ml. blood)					
8 days before	8.8	7.3	7.3	7.7	9.0	8.2
1 day before	7.8	7.1	7.2	7.0	8.0	6.5
6 days after	7.1	7.2	7.9	6.5	7.7	7.9
13 days after	8.4	8.0	6.5	7.0	7.0	7.4
20 days after	9.2 1/	8.7 1/	6.6	7.1	7.0	7.9
27 days after	9.8 1/2/	9.3 1/2/	6.9	7.0	7.3	8.3
34 days after	10.4 1/2/	10.2 1/2/	6.7	7.2	8.2	8.5
41 days after	10.5 1/2/	10.3 1/2/	6.9	8.0	7.8	8.2
Age at initiation supplementation	22	18	18	24	24	26

1/ Increased above other groups receiving only trace minerals P = 0.02 to <0.01.

2/ Increased above presupplemental value P = 0.02 to <0.01.

calves rations are not supplemented with iron, the hemoglobin level will reach a normal value after 3 or 4 months, or after the calf has had a considerable intake of forage. The requirements for iron are not well defined but it is felt that iron should be added to milk replacers so that the calf will receive about 100 milligrams per day as ferric sulfate.

Copper -- A copper deficiency, like iron, is also denoted by a low hemoglobin level in the blood. Loss of appetite or a depraved appetite, and graying of the hair coat are also characteristic of this deficiency. Copper deficiency may be complicated by other nutritional defects, such as excess of molybdenum. Copper deficiency can occur even in the presence of what is considered a normal amount of copper in the forage.

The requirements for copper are about 1/10 of that of iron or about 5 milligrams of copper per 100 pounds of body weight. A copper supplement is usually added to milk replacers. It is also advisable to add copper to the starter ration. It can be added by using a mineralized salt that contains 1 ounce of copper sulphate per 100 pounds of salt.

Iodine -- A deficiency of iodine in the ration can produce goiterous calves at birth. The best treatment for this condition is through feeding of iodized salt in the ration of the dam. Iodized salt is generally used in the calf starter diets.

ENZYMES

During the past year there has been a considerable interest in possible use of various enzymes in animal feeding. Work conducted at several Experiment Stations has shown no significant improvement from the supplementation of vegetable milk replacers with an animal protease (pepsins), a plant protease (papain) or a plant amylase (malt diastase). Such enzymes theoretically should make the vegetable proteins more readily available to the calf through their digestive action. The possible use of enzymes to convert some of the disaccharides or starches to simple sugars has not as yet received sufficient study for any definite conclusion. Further work will need to be conducted before any definite conclusions can be made on the use of enzymes in calf feeding.

ANTIBIOTICS

During the past 10-year period considerable knowledge has been gained about the use of antibiotics in the diets and rations of animals. They are widely used in the diets of chickens, swine, and beef cattle feeding rations.

Antibiotics are now added to commercially mixed calf milk replacers and starters. The antibiotic in this instance is fed for a period of 10 to 12 weeks and has the effect of increasing the rate of gain and decreasing the losses due to scours. Quite likely, under practical conditions, the latter effect is the one of greatest importance since the effect on rate of growth disappears during the subsequent growth period. The mode of action of the antibiotics is not completely understood. Studies with dairy calves do not indicate an increased utilization or digestibility of the diet. The effect of the antibiotic seems to be through stimulation of the appetite and a consequent increase in feed intake. An intake of 30 to 80 milligrams of Aureomycin per calf per day is recommended. Milk replacers and starters usually contain 20 to 40 milligrams per pound of feed.

MILK REPLACER

Examples of the makeup of some milk replacers tried at some of the Experiment Stations are shown in table 8. It will be noted that dried milk products make up the principal constituents of the replacer. The replacers are usually mixed with water in a proportion to make them similar to whole milk. The directions of the manufacturer should be followed in feeding the replacer.

TABLE 8.--Table of examples of milk replacer formulas

Item	1	2	3	4	5
Dried skim milk	50[1]	50	49	50[2]	28
Dried whey	15	15	10	10	15
Dextrose (glucose)	7.7	11	7	7.75	7
Corn distillers solubles	10	10	15	10	
Oat flour	10	10	5	5	5
Dried Brewer's yeast	5	5		4.9	5
Bloodmeal			10	10	
Soybean flour					35
Vitamin A concentrate	.05	.05	.5	.22	
Vitamin D concentrate	.005	.005	-		
Irradiated yeast				.1	
Dicalcium Phosphate	1.75	+	1.7	2.5	2.0
Cu SO_4	+	+		+	+
Fe SO_4	+	+		+	+
Mu SO_4	+	+		+	+
Co SO_4	-	+		+	
Antibiotic	.5	.5	1	-	+
Percent Protein	28	24			

1/ Jour. Dairy Sci. 43, 1003 (1960).
2/ Jour. Dairy Sci. 33, 809 (1950).

CALF STARTER

The calf starter forms a bridge between the milk-feeding period and the time the calf is able to consume the same feeds as are fed the mature herd. It usually is supplemented with vitamins and minerals and may also contain some dried milk products. However, they need not be comples. Examples of a few typical starters are shown in table 9.

TABLE 9.--Examples of calf starters

Item	1	2	3	4	5	6	7	8
Cracked corn	501	440	195	149	390	400	356	285
Wheat bran	333	220	122	128	300	300	200	
Crushed oats		220	295	307	400	400	350	285
Linseed meal	166				200	149	200	
Soybean meal		110	122	128	280	280	360	400
Alfalfa meal					140	200	140	
Corn dist. solubles			244	257			100	
Dried skim milk (or whey)					100	150	100	
Molasses					100	100	160	
Bonemeal			12	13		20		20
Limestone or ($CaCO_3$)					10		10	
Di-calcium phosphate					10		10	
Salt (iodized)	10	10	12	13	10	10	10	10
Brewers' yeast					60			
Cobalt							x	
Vit. A + D concentrate					x		x	
Antibiotic					x			

PASTURE

In New Zealand, because concentrates are not generally readily available and because pastures are excellent, calves are not fed grain or hay. Although the calf is fed whole milk to about 2 months of age, at about 10 days of age it is also turned to pasture. The calves are usually rotationally grazed ahead of the milking herd when the pasture is immature and high in digestibility and nutritive value. In the United States some experimental work indicates such a plan is feasible during some seasons of the year. This method deserves more attention and should reduce the costs of raising herd replacements.

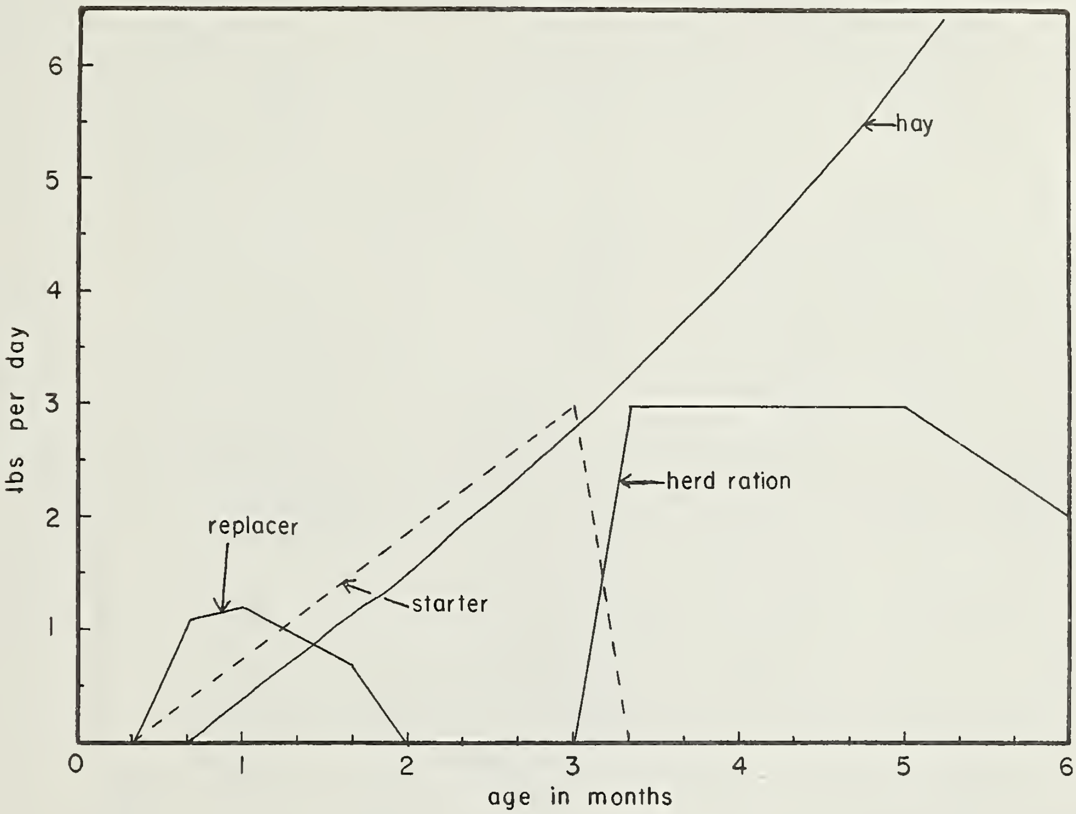

Figure 1.--Diagrammatic feeding schedule using milk replacers and calf starter. Colostrum fed first 3 days up to 8 lbs., 8 to 9 lbs. whole milk fed to 10 to 20 days of age and then start milk reolacer. Good quality hay necessary. With grass silage or poor quality hay feed more starter or herd ration. Feed no grain after 9 months.

Growth Through Agricultural Progress